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The Cognitive Neuroscience of Source Memory: Moving the Ball Forward

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Think about the last time you had a sudden insight about a new data set. Without consulting others, what made you think that "Aha!" moment represented a unique idea you generated "on the spot" rather than the remembrance of a great idea previously offered by a colleague in a hallway discussion of the data? More generally, how do we determine where a mental experience comes from?

Source memory is an umbrella term that refers to the processes involved in encoding, organizing, selectively reviving (e.g., reactivating, retrieving), cumulating, evaluating (e.g., weighting, comparing to expectations), and attributing (i.e., making inferences [judgments, decisions] about the source of) information during remembering. The concept encompasses, but is broader than, the idea of context memory (for reviews and further discussions see, e.g., Johnson, Hashtroudi, & Lindsay, 1993; Lindsay, 2008; Mitchell & Johnson, 2000). We routinely use these processes to solve everyday cognitive puzzles like the one described above or, for example, when remembering which U.S. Presidential candidate offered the tax plan you really like, remembering which pocket of your briefcase you put your keys in, deciding whether you turned off the stove or simply thought about doing so (Brandt, Bergström, Buda, Henson, & Simons, 2014), or determining whether you actually saw a video of an important news event or only imagined it (Ost, Vrij, Costall, & Bull, 2002).

Trivial errors in source memory can be inconvenient, and perhaps a little embarrassing, for example, raving about a new restaurant to a friend when she was the one who told you about it in the first place. But, source errors can sometimes have much more serious consequences, for example, remembering that you took your heart medicine when you only thought about doing so, mistaking a memory of a dream of being sexually abused as a child for a memory of something

that actually happened to you (see, e.g., Lindsay, 2014, for a review), believing that a voice is coming from an external source rather than one's own thinking (e.g., hallucinations, see, e.g., Johnson, & Raye, 2000; Woodward & Menon 2013 for reviews), or falsely confessing to having committed a crime (e.g., Shaw & Porter, 2015; see Henkel & Coffman, 2004 for a review).

Our understanding of the brain mechanisms associated with source memory has been rapidly accelerating over the past few decades (see, e.g., MacPherson, 2015; Mitchell & Johnson, 2009; Mitchell, 2016 for reviews). Refinements of cognitive theory and advancements in neuroscientific methodology (including imaging techniques and analysis approaches) are affording exciting synergistic progress. This special issue presents some of that progress. We set out to compile cutting-edge papers highlighting how behavioral, patient, and neuroimaging research is advancing our understanding of the brain mechanisms involved in source memory, broadly construed. The announcement for the issue challenged authors to submit papers that cover a broad range of: source specifying features, objective and subjective memory measures, processes (e.g., binding, revival, evaluation), moderating factors (e.g., individual differences, emotion, interventions), neuroscientific and analytical approaches, and populations in which source memory problems are of particular concern (e.g., aging, depression, schizophrenia). Those scientists who answered our call have not disappointed! What follows is a brief overview of the contributions in this special issue. To give you a sense of the range of the papers, and the topics they cover, we have imposed an artificial organization on them that highlights some of the key aspects of source memory, and especially interesting questions. Of course, this organization does not do justice to the breadth of topics/questions covered or the depth of the findings. You will certainly see other ways to mentally organize and assimilate the information these papers offer.

Memory Characteristics, Memory Binding, and the Nature of Memory Representations

Source memory depends on characteristics (i.e., features) that lend a sense of "episode-ness" or "event-ness" to our mental experiences (e.g., shape, color, smell, location, temporal, semantic, emotion, records of cognitive operations performed, etc.; Johnson et al., 1993). These are the details that separate one event from another in mind. Assessing the characteristics that are active in mind, and comparing them to our expectations about what the features of certain categories of events are like (e.g., that actually experienced events typically have a more logical temporal order than dreams; Chris has a deeper voice than Alex) helps us determine the source of our mental experience (e.g., Did it really happen or did I dream it? Did Chris or Alex tell me that joke?).

To be useful when making source memory decisions, the features of our on-going experience must be adequately encoded. Decades of research suggest, just as with perception, different brain regions process different categories of features (e.g., location, color, semantics) and more complex multidimensional items (e.g., faces, scenes, objects, task performed) during remembering (see Mitchell & Johnson, 2009; Mitchell, 2016 for reviews). However, memory of a single feature or isolated item is unlikely to produce the kind of rich remembering we typically characterize as source memory. Rather, the experience of a cohesive episode or event from a specific source relies heavily on associative, organizational, and/or binding processes that connect features, forming complex representations. Early neuroimaging evidence linked such processes (e.g., memory binding) to activation in (especially anterior) hippocampus, but it is becoming increasingly evident that other brain areas, including other medial temporal regions, prefrontal cortex, and parietal cortex are also involved (see Mitchell & Johnson, 2009; Mitchell, 2016 for reviews).

Memory binding/associative memory deficits have been identified in several groups that exhibit source memory deficits, including older adults (e.g., Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000) and people with schizophrenia (e.g., Burglen et al., 2004; Danion, Rizzo, & Bruant, 1999). Peterson, Gargya, Kopeikin, and Naveh-Benjamin (this issue) showed that, although more highly educated older adults demonstrated better frontal function than less educated older adults, as measured with neuropsychological tests, this did not seem to protect them from age-related associative memory deficits. Kuhlmann and Touron (this issue) showed that, like young adults, older adults were able to strategically improve both objective (accuracy) and subjective (ratings of difficulty) source memory performance by employing verbal and/or imaginal mediators to increase associations (see also, Kuhlmann & Touron, 2012). Such strategic processing should be reliant on prefrontal cortex (PFC). Given that aging disproportionately affects PFC, together these findings call into question the precise role of PFC in associative memory processes and/or the extent to which age-related changes in PFC underlie age-related associative deficits.

Evidence is accumulating that older adults' problems with binding and source memory are related, in part, to difficulties ignoring irrelevant features (e.g., Campbell, Hasher, & Thomas, 2010; Mitchell, Ankudowich, Durbin, Greene, & Johnson, 2013). To further explore this issue, Strunk and colleagues (this issue) measured event-related potentials (ERPs) in a *selective* binding task and examined neural oscillations at retrieval. Although theta synchronization over left parietal electrodes, thought to be related to amount of information retrieved, suggested that young and older adults retrieved equivalent amounts of information, brain-behavior correlations suggested that this information contributed to accurate source memory performance only for young adults. One interpretation of this finding is that older adults'

difficulty ignoring the irrelevant features during encoding (i.e., problems selectively binding only the relevant information) resulted in more irrelevant (i.e., non-diagnostic) information being retrieved at test (see also Mitchell et al., 2013). Beta desynchronization over centroposterior channels, presumably related to executive function, was positively correlated with source memory performance only in the older adults. The authors argue that together these results suggest that older adults' inability to ignore irrelevant information may result in greater engagement in episodic reconstruction processes during remembering.

One of the hottest issues in the source memory domain of cognitive neuroscience is more precisely identifying how multidimensional "items" or "events" are represented, and specifying the associated brain areas and/or patterns of brain activity. van den Honert, Johnson, and McCarthy (this issue) used a methodologically and analytically novel approach by applying multivariate pattern classification analysis (MVPA) -- which examines distributed patterns of activity of voxels within regions rather than just univariate differences in mean activity between regions -- to directly query whether feature combinations are represented in a feature-based or holistic manner, and what brain areas are involved. They found evidence of holistic representation in the parahippocampal cortex. In addition to informing the nature of the representations that result from feature binding in memory, the finding supports the idea that binding mechanisms are not unique to the hippocampus proper.

Reviving and Evaluating Information, Reinstatement Effects

Source memory also involves *selective* revival and evaluation (i.e., monitoring) of memorial information, and early neuroscientific research with lesion patients, as well as the earliest positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) studies of source memory, quickly focused attention on the frontal cortex as a primary region

involved in such processes during remembering (see, e.g., MacPherson, 2015; Mitchell & Johnson, 2009 for reviews). Since then, other regions have been identified as important as well, including lateral posterior parietal cortex and subregions of the medial temporal lobes (MTL; see, e.g., Mitchell, 2016 for further discussion).

One especially active line of inquiry involves understanding how the brain recapitulates or reinstates encoding activity during later remembering, how we assess and evaluate the match between activity at encoding and test, and how the degree of match influences source decisions. Liang and Preston (current issue) combined a novel imagery task and MVPA to show that patterns of encoding activity in MTL were reinstated during successful source retrieval. There was a gradient of content-specific reinstatement that predicted accurate source memory in the hippocampus: reinstatement of person information in anterior hippocampus was related to source accuracy as was reinstatement of place information across the entire hippocampal axis. There were also gradients evident in surrounding MTL cortex: perirhinal cortex showed reinstatement of people information and parahippocampal cortex showed reinstatement of places and objects. Moreover, consistent with the idea that true and false memories typically arise via the same cognitive and brain mechanisms (e.g., Johnson et al., 1993; Johnson & Raye, 2000; Mitchell & Johnson, 2000, 2009), source errors were predicted by reinstatement of incorrect source content in MTL. Using a different paradigm, Karanian and Slotnick (this issue) provide converging evidence for this idea by showing that true memories and false memories for location similarly activated the parahippocampal cortex. Such findings support the idea that inferences about the origin of a "memory" rely on how much information from various categories of characteristics is active during remembering, regardless of where that information actually came from (e.g.,

perception or reflection), and how that information seems to "match" expectations about the encoding experience (Johnson et al., 1993; Tulving, & Thomson, 1973).

Obviously, that is not to say there is no neural evidence differentiating true from false memories. O'Neill and Diana (this issue) explored the neural correlates of *context borrowing*, alternatively referred to as *content borrowing* (e.g., Lampinen, Meier, Arnal, & Leding, 2005) or *feature importation* (e.g., Lyle & Johnson, 2006; see also Henkel, Franklin, & Johnson, 2000 for one of the first systematic demonstrations). This is a phenomenon by which features from an actually experienced event are incidentally activated during processing of a related event, thereby allowing for a comingling of features of the target and related events resulting in a rich, compelling false memory. It is not yet clear whether this borrowing occurs at encoding or retrieval, or both. In any event, the study by O'Neill and Diana examined brain activity during retrieval and showed greater parahippocampal activation (presumably associated with context retrieval) for source errors based on context borrowing than for true memories, but greater hippocampal activity (which they argue signals retrieval of episodic binding information) for correct source memories than sources errors. The authors argue that this pattern supports the idea that false memories resulting from context borrowing occur when source information is retrieved without the proper item-context binding that helps differentiate one event from another related, but distinct, event. Why and exactly how this occurs are important next questions.

Thakral and colleagues (this issue) used MVPA to analyze reinstatement effects in the core recollection network (including hippocampus, angular gyrus, medial prefrontal cortex, retrosplenial/posterior cingulate cortex, middle temporal gyrus) related to *Remember* vs *Know* responses. Remembered items could be decoded in network regions, but surprisingly so could items given a Know response. The findings suggest reinstatement of encoding-related activation

at test is not unique to recollection. Of course, considerable additional work is needed to identify exactly what is being reinstated as people experience familiarity or recollection. It is of note that Remembered items could also be decoded in dorsolateral prefrontal cortex—a region where univariate analyses did not show activity associated with remembering. This supports the now common idea that multivariate analyses of within region differences in activation may offer insights beyond those provided by univariate analyses that rely on mean signal differences between regions.

Subjective Experience

People's subjective experiences during remembering, such as a sense of vividness or confidence, have long been of interest to researchers studying source memory (e.g., Johnson, 1988). It is not surprising then that there is substantial focus currently on specifying the brain areas, networks, and/or patterns of brain activity associated with subjective experiences that accompany memory for source. For example, in the Karanian and Slotnick (this issue) paper mentioned above, activity in parahippocampal cortex tracked the subjective strength of false memories, as high confidence false memories for location activated the parahippocampal cortex to a greater degree than low confidence false memories for location.

There seems to be little doubt at this point that posterior parietal cortex is involved in remembering complex (i.e., multi-featured) information. Its precise role is still of some debate, however (see, e.g., Mitchell, 2016 for review). Among the ideas that have garnered support are that (a) posterior parietal cortex is involved in processing (e.g., accumulating, binding) multiple features associated with a complex, multidimensional event, and/or (b) it specifically supports the subjective experiences associated with recollection, such as confidence, vividness, etc. Consistent with this second idea, Simons, Peers, Mazuz, Berryhill, and Olson (2009) found that

patients with bilateral parietal lesions were not less accurate than controls on a source memory task, but they were less confident in their source judgments. In this issue, Ciaramelli and colleagues show that, compared to a control group, parietal lesion patients' source accuracy for conjoint features (i.e., color+location information) was not impaired, nor did they provide fewer *Remember* than *Know* responses overall. But, they were significantly less likely than controls to give Remember responses specifically for those items for which they had correctly identified the conjoint source. Rather than being related to retrieving the conjoint features, the subjective experience of *remembering* in the patients seemed to be related recognition confidence. Hence, the parietal patients did not seem to be engaging in appropriate monitoring of the multidimensional representations they seemed able to retrieve—a kind of objective/subjective source memory dissociation (see Boywitt, Kuhlmann, & Meiser, 2012 for behavioral evidence of a similar dissociation in older adults). Together with other data in the literature, this seems to suggest that posterior parietal cortex is somehow involved in evaluating multidimensional information with respect to a subjective memorial experience or mapping the available objective information onto a subjective response. Data provided by King and colleagues (this issue) raise the question of whether involvement of posterior parietal cortex varies according to the actual source of the information, specifically whether it is external/perceived or internal/imagined. Such differences would be consistent with the view that source monitoring takes advantages of inherent differences in features across these categories of sources in discriminating between them (e.g., Johnson et al., 1993).

Bowen et al. (this issue) advance our understanding of how emotion impacts phenomenal experiences associated with source memory by providing fMRI evidence that there is greater reinstatement of encoding activity at test in the visual cortex for information originally

experienced in a negative than a positive or neutral visual context. As they suggest, this may help explain why memory for negative events often is associated with higher ratings of recollection, subjective vividness, and amount of detail (see Mitchell & Johnson, 2009 for review).

The Self and Source Memory

From a source memory perspective, the "self" is an especially important and interesting concept (see Mitchell & Johnson, 2009 for further discussion). Leynes, Askin, and Landau (this issue) recorded ERPs during a novel behavioral paradigm assessing source memory for whether words were presented at encoding from a first- or third-person visual perspective. Consistent with the self-reference literature, item recognition was better for words acquired from a first-person perspective than third-person. Source memory, on the other hand, did not differ between the two conditions. Nevertheless, the ERP data suggested that, consistent with the source monitoring framework (Johnson et al., 1993), different visual information was activated and/or monitored during remembering in the two conditions.

Other evidence suggests that self-referential processing may improve source memory (i.e., *source self-referential effect*, e.g., Durbin, Mitchell, & Johnson, 2017) in young adults. Healthy older adults' source memory may also benefit from such processing, attenuating, but not always eliminating, the deficits in source memory typically associated with aging (e.g., Dulas, Newsome, & Duarte, 2011; Hamami, Serbun, & Gutchess, 2011; Rosa & Gutchess, 2011; Serbun, Shih, & Gutchess, 2011). In contrast, Wong and colleagues (this issue) show that self-referential processing did not attenuate the source memory impairments typically associated with Alzheimer's disease (AD) nor did it improve source memory performance in those with behavioral-variant frontotemporal dementia (bvFTD). However, in spite of the similar behavioral results for these two patient groups, findings from voxel-based morphometry suggest

that AD and bvFTD impair different components of self-referential processing. While reductions in the self-referential effect were associated with atrophy in anterior-dorsal cortical midline structures in both groups, there was additional involvement of the posterior cortical midline structures in the AD group and anterior-ventral cortical midline structures in the bvFTD group. Such findings inform both the memory deficits associated with these disorders and the function of various subregions of midline structures involved in self-referential processing and in source memory.

Reality monitoring refers to a subset of source monitoring that involves differentiating between self (internally)- vs other (externally)-generated information (Johnson & Raye, 1981). Investigators interested in understanding the reality monitoring problems associated with schizophrenia (e.g., hallucinations) have been particularly interested in the medial prefrontal cortex (mPFC) because of its putative role in reality monitoring (e.g., Simons, Davis, Gilbert, Frith, & Burgess, 2006). Subramaniam, Ranasinghe, Mathalon, Nagarajan, and Vinogradov (this volume) showed both behavioral and neural dissociations in mPFC between patients with schizophrenia and healthy control participants with respect to the impact of mood on source memory for self- vs other-generated information. Such findings may help further not only our understanding of the brain mechanisms of schizophrenia, but attempts at designing behavioral and neuroscientific interventions, as well.

Consistent with a role for mPFC in reality monitoring, Mammarella, Domenico, Palumbo, and Fairfield (this issue) show that transcranial Random Noise Stimulation (tRNS) applied to mPFC during encoding of neutral and emotional seen vs imagined words improved reality monitoring performance overall for both young and older adults relative to sham stimulation. Subsequent analyses suggested that older adults' memory for positively valenced

imagined words seemed to particularly benefit from tRNS. The authors argue this supports the idea of a role for mPFC in the imagination of particularly positive information, and may suggest an intervention for age-related reality monitoring difficulties.

Individual and Group Differences

One individual difference among otherwise healthy people is the tendency to experience hallucinations, referred to as *hallucination-proneness*. This proneness has been the focus of much discussion in the clinical domain, as it is argued to support a continuum model of psychosis (see, e.g., Johns & Van Os, 2001 for discussion). Garrison, Moseley, Alderson-Day, Smailes, Fernyhough, and Simons (this issue) asked whether hallucination-proneness is related to impairment on a reality monitoring task (perceived vs imagined or self vs experimenter as speaker), an internal source memory task (covert vs overt speech), or both. In no case did performance correlate with hallucination-proneness. Because there is substantial evidence in the literature of a relationship between hallucinating and impairment on similar laboratory-based reality monitoring tasks in people with schizophrenia, Garrison et al. argue that the current findings are inconsistent with a continuum model of psychosis. There are many unanswered questions here, though, and the authors make suggestions for important further inquiry.

On a very different note, Hayes, Hayes, Williams, Liu, and Verfaellie (this issue) looked at cardiorespiratory fitness (CRF) in older adults as an individual difference that might affect source memory. The hypothesis was that better CRF might attenuate some effects of aging on the brain that are related to poor associative encoding (and hence, reduced source memory performance). Indeed, CRF was predictive of source memory performance, as older adults with high CRF did better in remembering face-name pairs than did those with low CRF. They also found evidence of a role for CRF in both reduced age-related differences (e.g., in the thalamus,

medial temporal lobe, and left inferior and bilateral medial frontal gyri) and greater age-related differences (primarily in bilateral middle/superior and right inferior and medial frontal gyri) in fMRI activity at encoding. Although activity in many of these areas was positively related with source memory performance, activity in medial frontal gyrus mediated the relationship between CRF and source memory performance.

Papers by Meusel, Grady, Ebert, and Anderson (this issue) and Ankudowich, Pasvanis, and Rajah (this issue) aimed to dissociate age-related and memory-ability-related differences in the brain activation associated with source memory. Based on neuropsychological memory test performance, Meusel et al. grouped older adults as high functioning (Hi-Old) and low functioning (Lo-Old), and they compared both groups to young adults on a source memory task (heard vs seen words) using fMRI at retrieval. As might be expected, the behavioral results showed that the Lo-Old group performed more poorly than the young adults, and the Hi-Old group performance was numerically between Lo-Old or Young but it did not different significantly from either. In young adults, brain activation in common source memory retrieval areas, such as lateral and medial PFC, posterior parietal cortices including precuneus, and bilateral insula, was *negatively* associated with task accuracy. The Hi-Old and Lo-Old groups, on the other hand, showed *positive* activity-accuracy associations in parietal regions (precuneus, right inferior parietal lobule) and medial PFC (dorsal anterior cingulate cortex). They suggest this pattern reflects age-related compensatory activity in these areas, known to be associated with retrieval success. Ankudowich et al. scanned a large number of adults across the lifespan at both encoding and test while performing spatial and temporal source memory tasks. Multivariate behavior partial least squares analyses (B-PLS) showed complex interactions of age, performance, and encoding/retrieval phase-related activity. Specifically: activity in both phases

increased with age but decreased with performance in fusiform, middle occipotemporal and inferior parietal cortices; activity in dorsolateral PFC increased with age at encoding but with performance at retrieval; and activity in right ventrolateral PFC and bilateral hippocampus increased with age during retrieval and showed opposite relationships with performance during encoding vs retrieval. Findings such as these are important for moving us forward in our understanding of the complex impact of age on source memory. But, more generally, they serve to caution us about interpreting *apparent* age-related changes in brain activity.

A different sort of cautionary note is raised by the findings of Paige, Ksander, Johndro, and Gutchess (this issue) explored the impact of culture on the brain mechanisms of source memory. They showed that during successful encoding Americans and East Asians may differentially recruit key brain areas, such as fusiform cortex and hippocampus, involved in processing complex visual features and binding, respectively. This has important implications for our understanding of source memory, and suggests that assessing ethnicity or cultural differences in our samples may be important for interpreting relevant brain data.

El Haj and colleagues (this issue) compared a group of patients with Korsakoff's syndrome to a healthy control group on tests of external source monitoring (did the experimenter place the object into the white or black box?), internal source monitoring (did you place the item into the box or imagine putting it into the box?), or reality monitoring (did you or the experimenter place the object into the box?). They found that the Korsakoff's group performed significantly more poorly than the control group on the external and internal source monitoring tasks, but there was no group difference on the reality monitoring task. They suggest this may signal a preservation of ability to recognize oneself as actor. Tying this to possible brain disruptions associated with Korsakoff's syndrome will be an important next step.

Interventions

One goal of cognitive neuroscience is to facilitate development of interventions. Several of the studies discussed above point to possible interventions for improving source memory (e.g., Kuhlmann and Touron, this issue; Mammarella et al., this issue; Subramaniam et al., this issue). Deason and colleagues (this issue) created a novel "shopping" memory task and showed that older adults with MCI who were probed with questions designed to encourage metacognitive processing (e.g., recall-to-reject, distinctiveness heuristic) performed better than older adults with MCI who underwent standard memory test instructions. This reflected a decrease in false alarms and more conservative response criterion in those in the metacognitive condition, rather than a change in hit rates. Although these findings are encouraging with respect to interventions for older adults with MCI, the authors caution against generalizing to other older adult groups. For example, in their study, older adults without MCI did not benefit from the metacognitive instructions, and given that such metacognitive processes tend to rely on prefrontal functioning, the results may not generalize to those with more severe prefrontal pathology such as those with Alzheimer's disease. Hence, relatively easy and low-cost "strategy" interventions, such as those explored in this study, may have a "sweet spot" in which they work.

Measuring Source Memory and Differentiating It From Other "Kinds" of Memory

Much research and theorizing has focused on how best to measure and model source memory (e.g., Banks, 2000; Batchelder & Riefer, 1990; Hautus, Macmillan, & Rotello, 2008; Meiser, & Bröder, 2002; Slotnick, Klein, Dodson, & Shimamura, 2000). One alternative to "traditional" behavioral measures of source memory (e.g., Pr [correct source identification minus incorrect source identification divided by old-new item recognition]), are Multinomial Processing Tree (MPT) models of source memory, of which there are many. Proponents of MPT

models argue that one advantage of this approach is that it provides separate measures of item memory, source memory, and guessing (e.g., Batchelder & Riefer, 1990; Meiser & Bröder, 2002), relatively uncontaminated by the other components. Across two experiments with young and older adults, and using very different memory paradigms, as well as patient groups (focal hippocampal lesions and older adults with mild memory problems), Cooper and colleagues (this issue) showed that conclusions about memory differences between groups depended on the way memory was measured. Differences in outcomes of comparisons between groups varied not just between a traditional source memory measure (Pr) and MPT models, but also between different MPT models. These findings highlight the need to be explicitly mindful of the assumptions of a particular measure when interpreting source memory findings.

There has also been much discussion in the source memory domain comparing and contrasting source memory with other memory concepts such as context memory, episodic memory, recollection (see, e.g., Johnson, 2005 comments on Siedlecki, Salthouse, & Berish, 2005; Qin, Raye, Johnson, & Mitchell, 2001 comments on Yonelinas, 1999). This conversation might be considered a non-starter because, from a source monitoring view, all cognitive tasks, including various memory tasks such as recall, recognition, remember/know, and source identification recruit from the same set of component cognitive processes. What may vary is the combination of component processes drawn upon in any given situation (e.g., between tasks, within tasks using different stimulus types, within tasks with different set sizes; see, Johnson, 2005 for further discussion). Neuroscientific approaches may provide leverage for identifying the precise component processes of remembering involved under different circumstances and/or how they are orchestrated differently in different circumstances, by identifying common and distinct brain correlates. In the current issue, Stamenova and colleagues provide some such evidence.

They tested patients with focal lesions in various frontal regions (medial polar, right dorsolateral, left dorsolateral, and right frontotemporal), as well as in temporal (but not the medial temporal lobe) and parietal regions, to assess the necessity of these regions for recollection. Whereas lesions in medial polar and right dorsolateral prefrontal cortex and temporal and parietal cortex negatively impacted remember judgments (ostensibly measuring recollection), lesions in right superior lateral temporal and inferior prefrontal cortex did not. Importantly, cued recall, recognition, know responses (presumably measuring familiarity), and source recall were all intact in these groups. Mapping such patterns onto potential component processes of cognition is an important step.

We hope this incredibly cursory overview of the contents of this special issue has whet your appetite. We have highlighted only a small fraction of the findings that are found among its pages. We invite you to dig in and explore, knowing that in spite of the many questions answered, many more have been raised: Moving the ball forward.

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